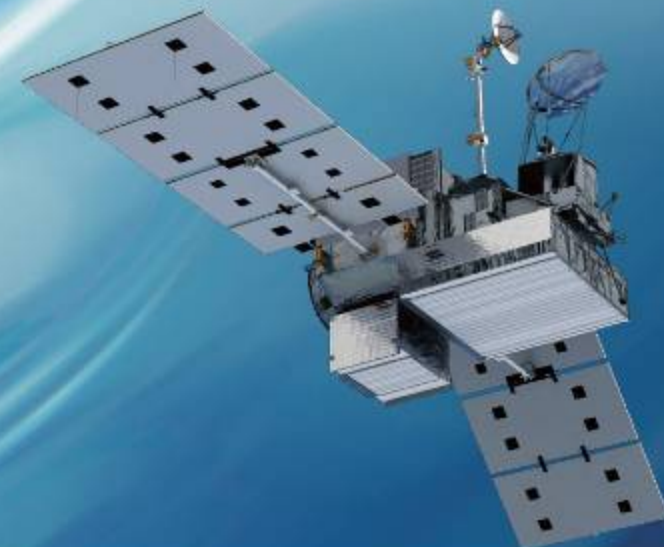# JAXA TRMM/GPM Program Status

Riko OKI (JAXA/EORC)

Tropical Rainfall Measuring Mission (TRMM)

❉ **Precipitation Radar (PR) onboard the TRMM satellite completed on 1st April 2015.**

❉ **TRMM re-entered the atmosphere at 12:55 p.m. on June 16, 2015 (Japan Standard Time) over the South Indian Ocean.**

❉ Major characteristics

  ✓ Focused on rainfall observation. First instantaneous rainfall observation by three different sensors (PR, TMI, VIRS). PR, active sensor, can observe 3D structure of rainfall.

  ✓ Targeting tropical and subtropical region, and chose non-sun-synchronous orbit (inc. angle 35 degree) to observe diurnal variation.

❉ Major achievement in Japan

  ✓ Demonstration of high quality and high reliability of a satellite onboard precipitation radar

  ✓ Improvement of precipitation retrieval from passive microwave radiometer by PR 3D observation

  ✓ Pioneering precipitation system climatology by PR observation
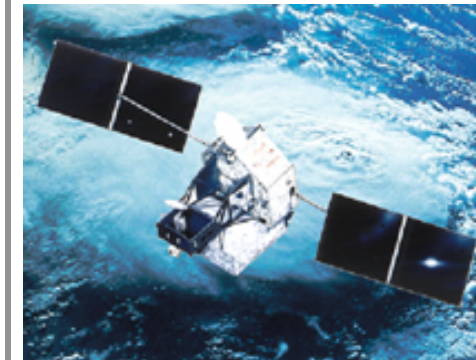
US-Japan joint mission

Japan: PR, launch

US: satellite, TMI, VIRS, CERES, LIS, operation

Launch	28 Nov. 1997 (JST)
Altitude	About 350km (since 2001, boosted to 402km to extend mission operation）
Inc. angle	About 35 degree, non-sun-synchronous orbit
Design life	3-year and 2month (still operating)
Instruments	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS) Lightning Imaging Sensor (LIS) CERES (not in operation)

A development of the TRMM PR Climate Records

* The sensitivity of PR has been changed over ~17 years operation period.

    * Methods mitigating discontinuities are underdevelopment.
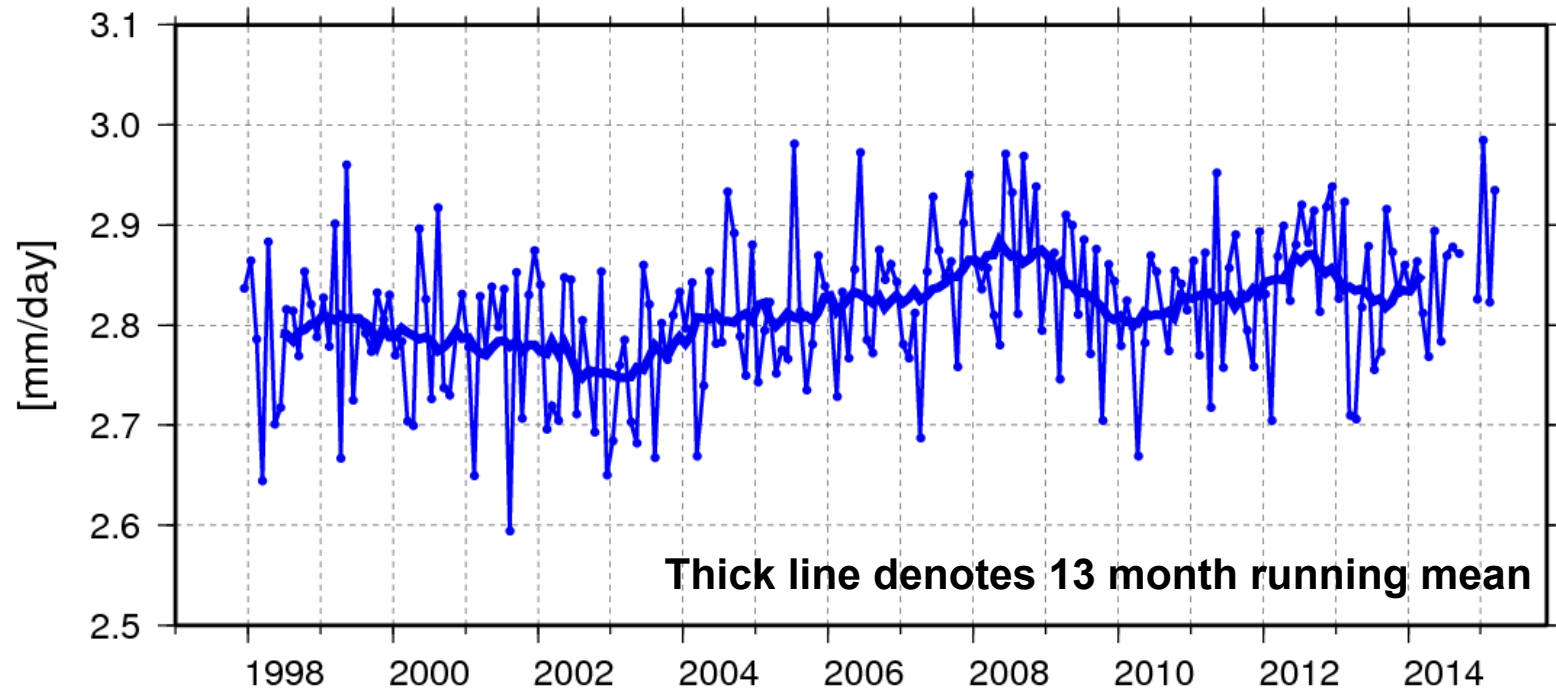
Storm Height anomaly (35S-35N ocean)
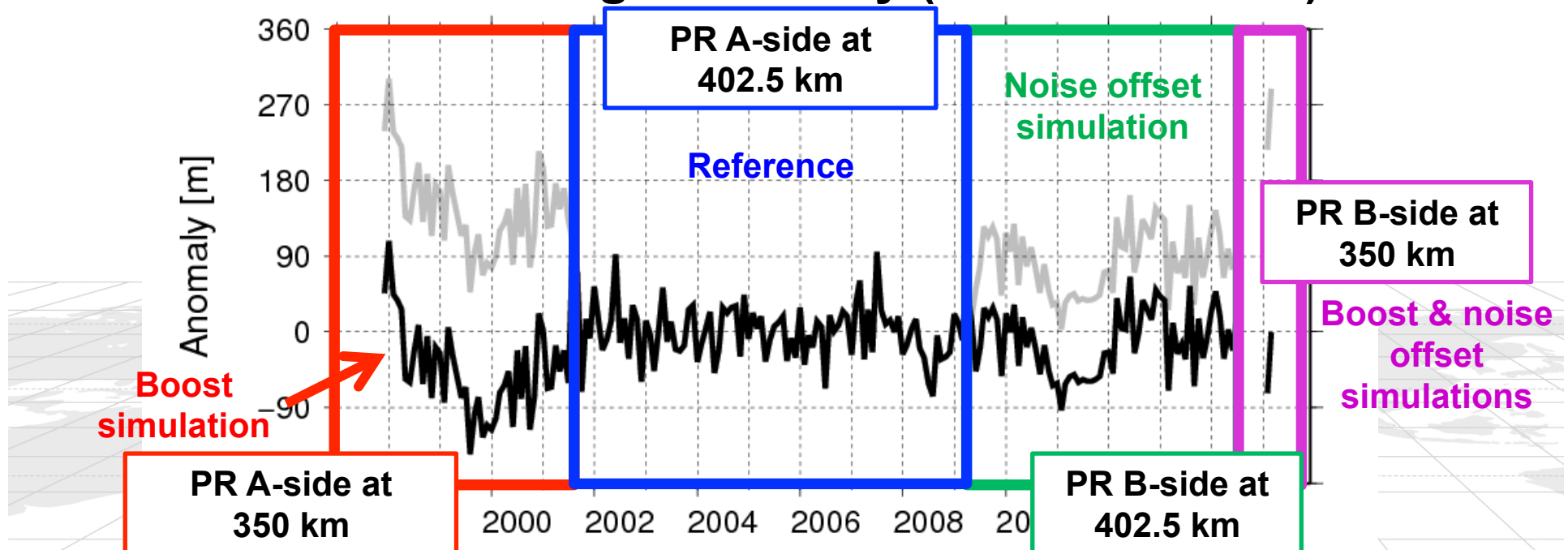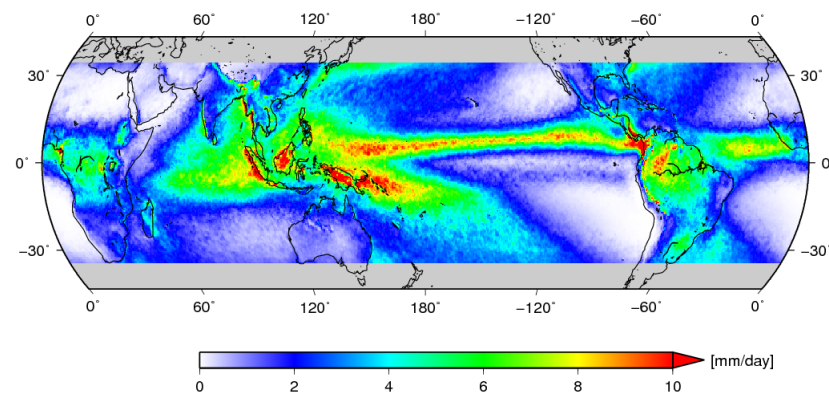
Long-term continuous PR precipitation record (interim)

TRMMM PR nearSurfRain (35S–35N Globe)

Thick line denotes 13 month running mean

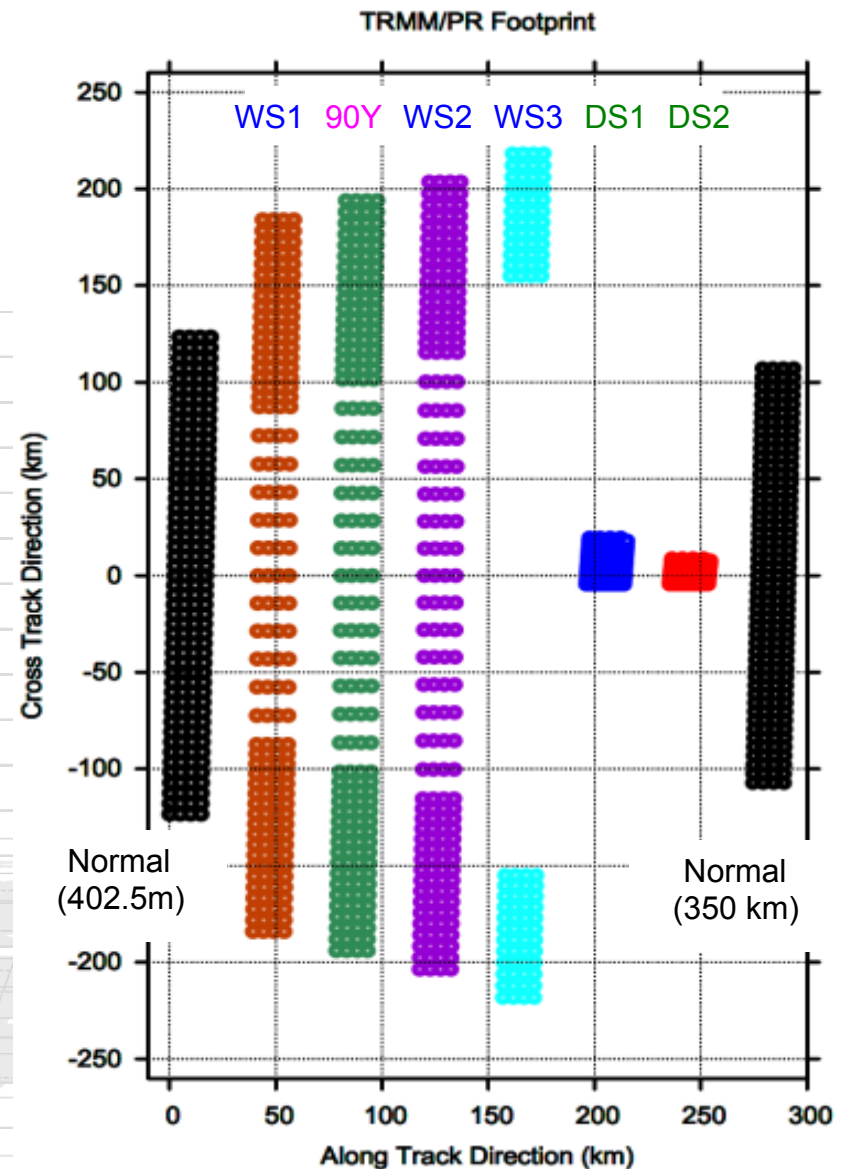**17+ years PR surface precipitation climatology (Dec. 1997 – Mar. 2015)**
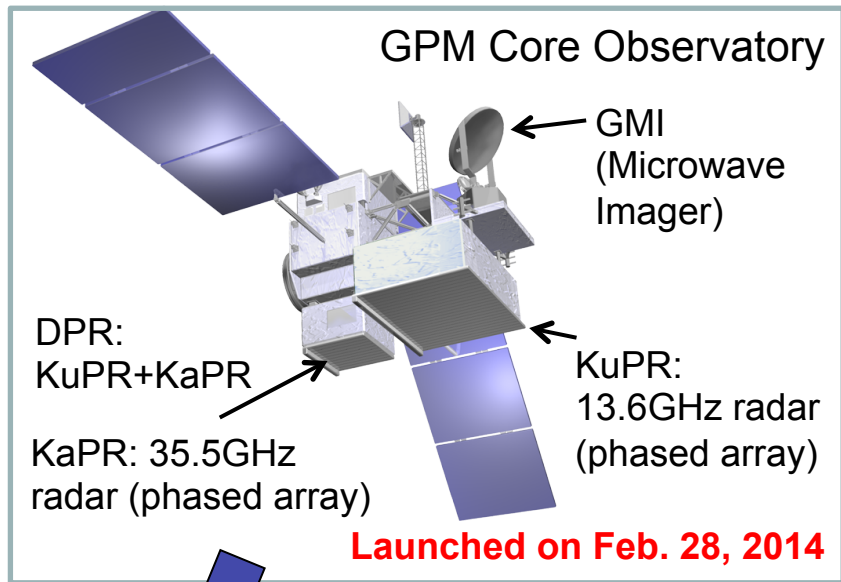
TRMM/PR EOM (End of Mission) Status

① Wide Swath Experiment (WS)
② 90deg. Yaw Experiment (90Y)
③ Dense Sampling Experiment (DS)

EOM Schedule

	Date	upload command	Altitude
Normal (402.5m)			
	27-Oct-2014	Wide Swath #1	387.29 km
WS1	19 days		
	15-Nov-2014	90deg-Yaw	382.47 km
90Y	9 days		
	24-Nov-2014	Wide Swath #2	379.67 km
WS2	23 days		
	17-Dec-2014	Wide Swath #3	373.40 km
WS3	19 days		
	5-Jan-2015	Dense Sampling #1	366.81 km
DS1	19 days		
	24-Jan-2015	Dense Sampling #2	360.68 km
DS2	13 days		
	6-Feb-2015	Normal Obs. (350 km)	355.85 km
	41 days		
Normal (350 km)	19-Mar-2015	Normal Obs. Ends	339.63 km
	9 days		
	28-Mar-2015	Passivation	334.74 km

TRMM/PR Footprint

WS1 90Y WS2 WS3 DS1 DS2

Cross Track Direction (km)

Normal (402.5m)

Normal (350 km)

Along Track Direction (km)

Global Precipitation Measurement (GPM)

GPM Core Observatory

GMI (Microwave Imager)

DPR: KuPR+KaPR

KuPR: 13.6GHz radar (phased array)

KaPR: 35.5GHz radar (phased array)

Launched on Feb. 28, 2014

Constellation satellites by international partners

Core Observatory by NASA-JAXA

* **Knowledge regarding climate variations**
 * Continuous precipitation observation data from TRMM to GPM
* **Highly reliable knowledge regarding precipitation science**
  * Observation of cumulonimbus, tropical cyclones, diurnal variations of precipitation in the tropics
    * →Observation of precipitation over the mid-to-high latitude frontal zones
* **Near-real-time precipitation information**
  * For numerical weather prediction
  * For flood alert/warning system, etc.
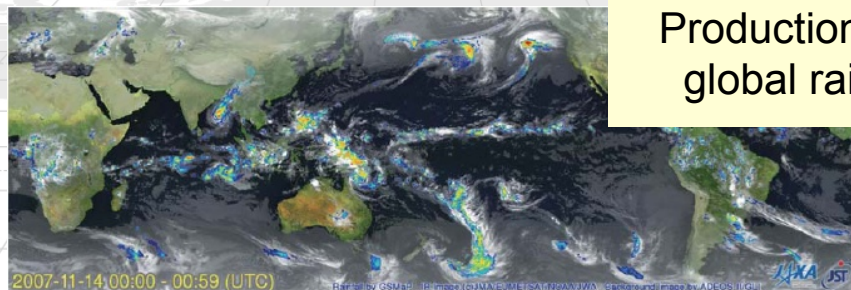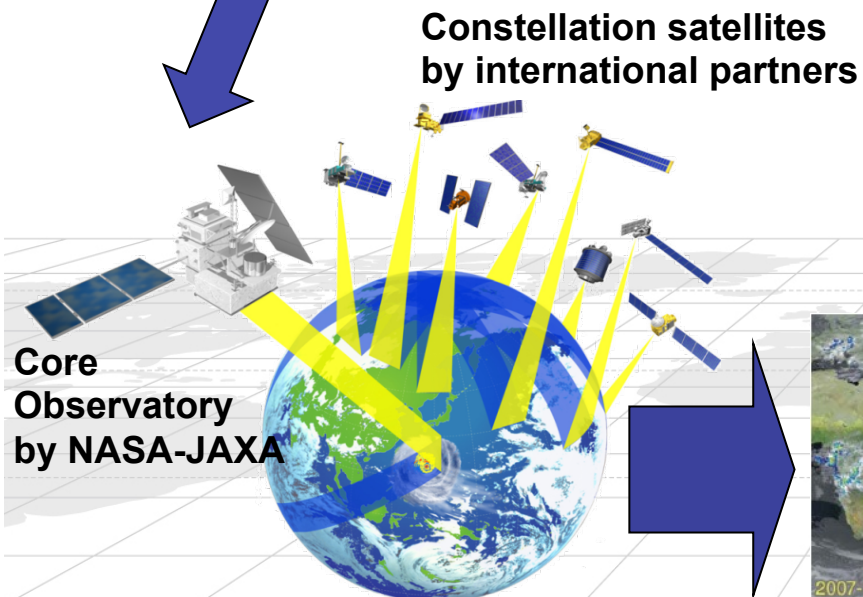
Production of hourly global rainfall map
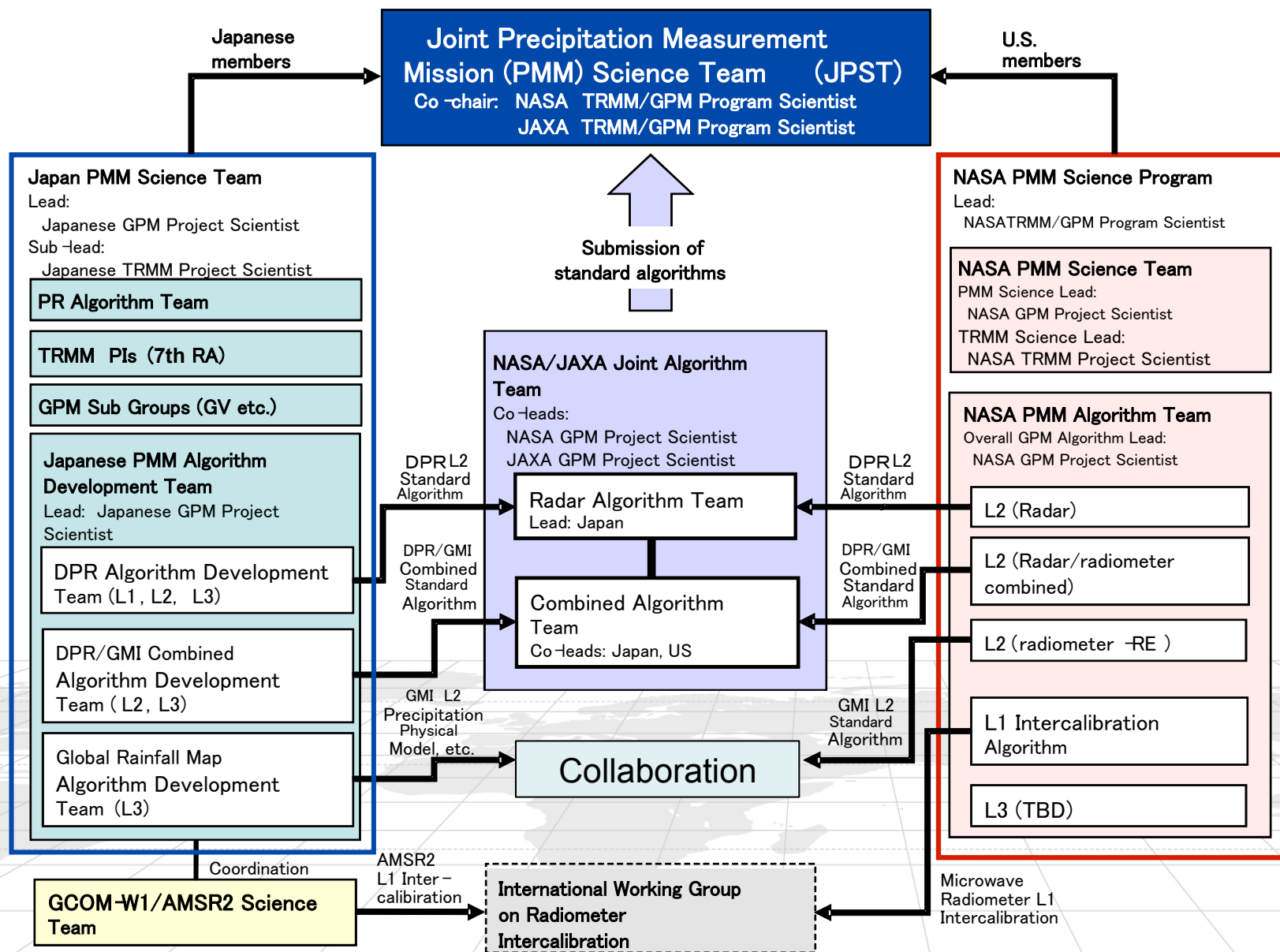
2007-11-14 00:00 - 00:59 (UTC)

Japanese PMM Science Team

- The Japanese PMM Science Team started in Apr. 2013 for three-year period.
  - 30 proposals for the 7th RA (JFY2013-2015)
    - It is the 7th RA since the first TRMM RA, and the 3rd as PMM
    - 23 + 2 with research cost proposals
    - 5 no cost transfer proposals including 3 from abroad
- The science team includes both TRMM and GPM activities.
  - Continue to focus on GPM algorithm development and related GV activities. Also includes more Application studies related to new research products, data assimilations, and model utilizations.
- New call for next 8th RA will be annouced this year.
  - A new science team will start in Apr. 2016.

Japan and U.S. PMM Science Framework
-- two joint algorithm development teams --

Japanese members →

Joint Precipitation Measurement Mission (PMM) Science Team (JPST)
Co -chair: NASA TRMM/GPM Program Scientist
JAXA TRMM/GPM Program Scientist

← **U.S. members**

Japan PMM Science Team
Lead:
Japanese GPM Project Scientist
Sub -lead:
Japanese TRMM Project Scientist

- PR Algorithm Team
- TRMM PIs (7th RA)
- GPM Sub Groups (GV etc.)

Japanese PMM Algorithm Development Team
Lead: Japanese GPM Project Scientist

- DPR Algorithm Development Team (L1, L2, L3)
- DPR/GMI Combined Algorithm Development Team (L2, L3)
- Global Rainfall Map Algorithm Development Team (L3)

Submission of standard algorithms ⬆

NASA/JAXA Joint Algorithm Team
Co -leads:
NASA GPM Project Scientist
JAXA GPM Project Scientist

- Radar Algorithm Team
  Lead: Japan
- Combined Algorithm Team
  Co -leads: Japan, US

NASA PMM Science Program
Lead:
NASATRMM/GPM Program Scientist

NASA PMM Science Team
PMM Science Lead:
NASA GPM Project Scientist
TRMM Science Lead:
NASA TRMM Project Scientist

NASA PMM Algorithm Team
Overall GPM Algorithm Lead:
NASA GPM Project Scientist

- L2 (Radar)
- L2 (Radar/radiometer combined)
- L2 (radiometer -RE)
- L1 Intercalibration Algorithm
- L3 (TBD)

DPR L2 Standard Algorithm

DPR/GMI Combined Standard Algorithm

GMI L2 Precipitation Physical Model, etc.

DPR L2 Standard Algorithm

DPR/GMI Combined Standard Algorithm

GMI L2 Standard Algorithm

Collaboration

Coordination

GCOM -W1/AMSR2 Science Team

AMSR2 L1 Inter - calibration

International Working Group on Radiometer Intercalibration

Microwave Radiometer L1 Intercalibration

DPR observation examples

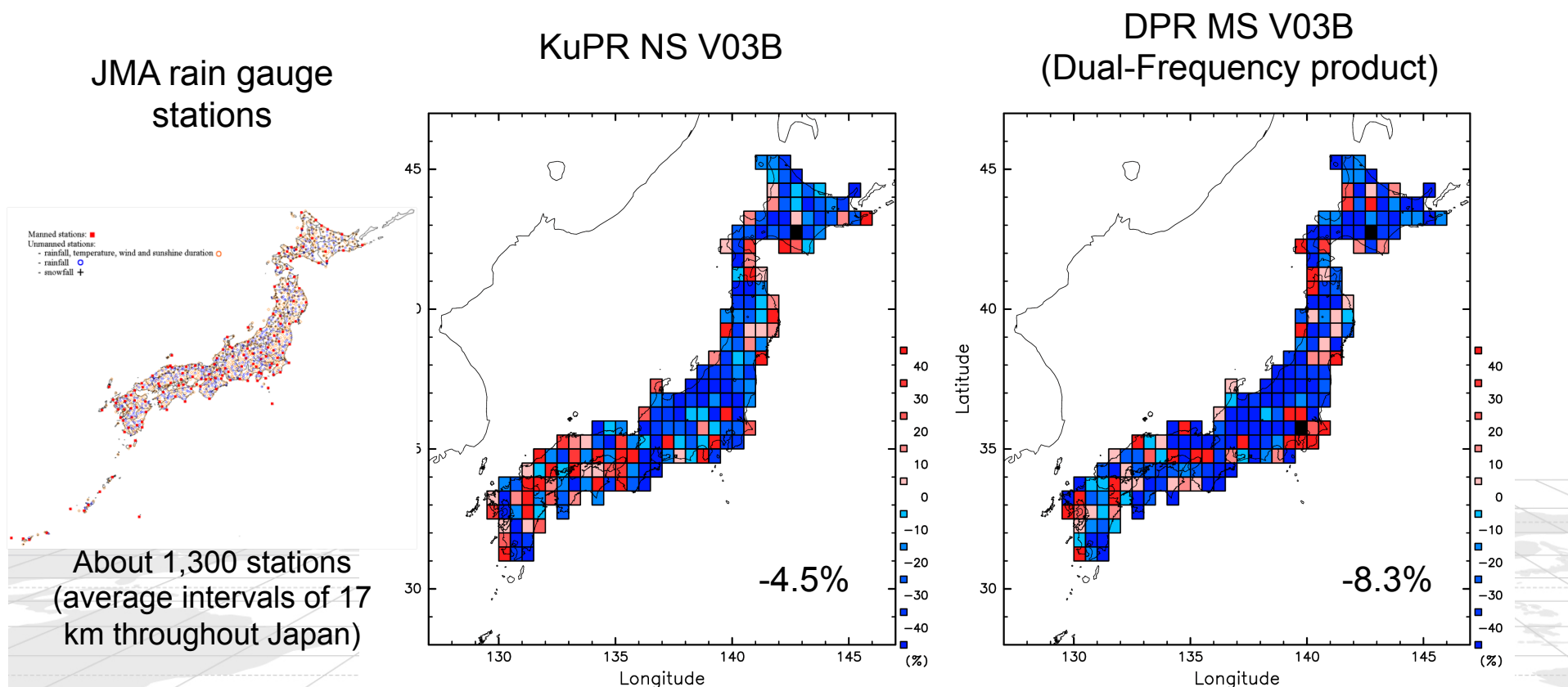Surface precipitation rate of GPM/KuPR averaged during March 2014 – June 2015 (V03B)

GPM/KuPR Surface Precip (0.5x0.5deg) : MAR2014–JUN2015

TRMM coverage
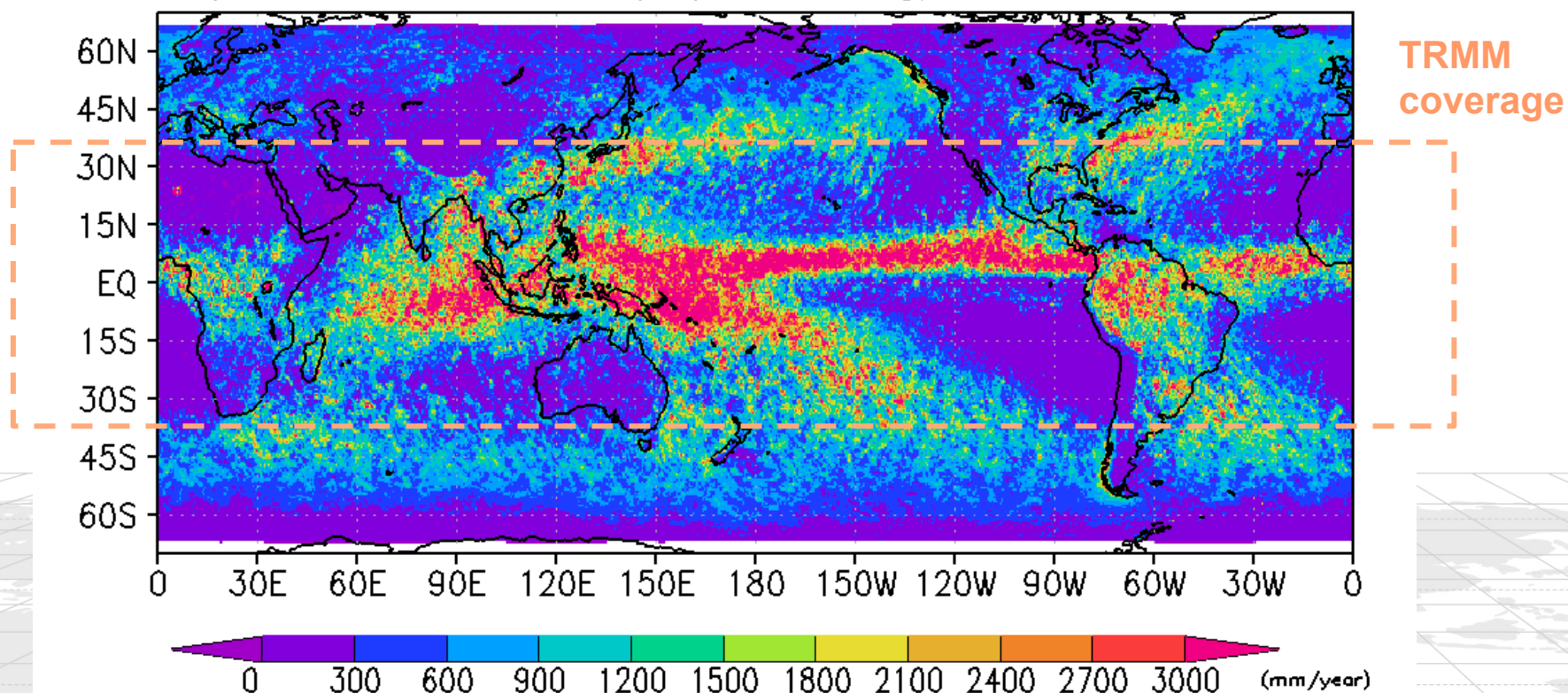
Evaluation of DPR product using JMA rain gauge network (1/2)

Biases of GPM/KuPR, GPM/DPR products with reference to **rain gauge network** by Japan Meteorological Agency (JMA)

Data period: **Apr. 2014 to Mar. 2015,** Satellite overpass cases only, 0.5x0.5 lat/lon grid

JMA rain gauge stations

About 1,300 stations (average intervals of 17 km throughout Japan)

KuPR NS V03B

-4.5%

DPR MS V03B
(Dual-Frequency product)

-8.3%

- Underestimation area is found, in particular, in the northern part of Japan.

Evaluation of DPR product using JMA rain gauge network (2/2)

Biases of GPM/KuPR, GPM/DPR products with reference to JMA **rain gauge network**
Data period: **Apr. 2014 to Mar. 2015,** Satellite overpass cases only, 0.5x0.5 lat/lon grid

**Rain cases only
(surf Temp. >6 C)**

JMA rain gauge stations
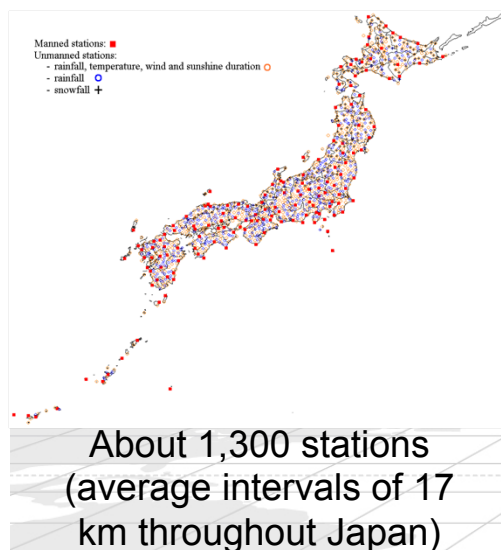
KuPR NS V03B

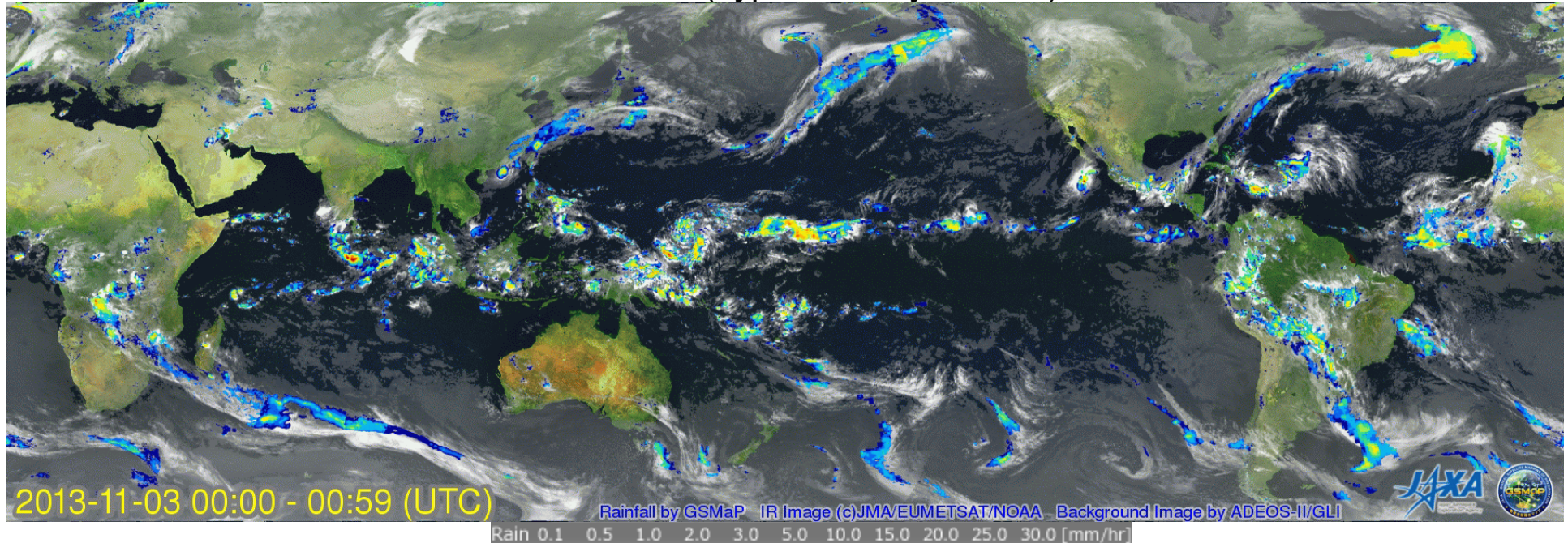DPR MS V03B
(Dual-Frequency product)

About 1,300 stations (average intervals of 17 km throughout Japan)

13.1%

3.9%
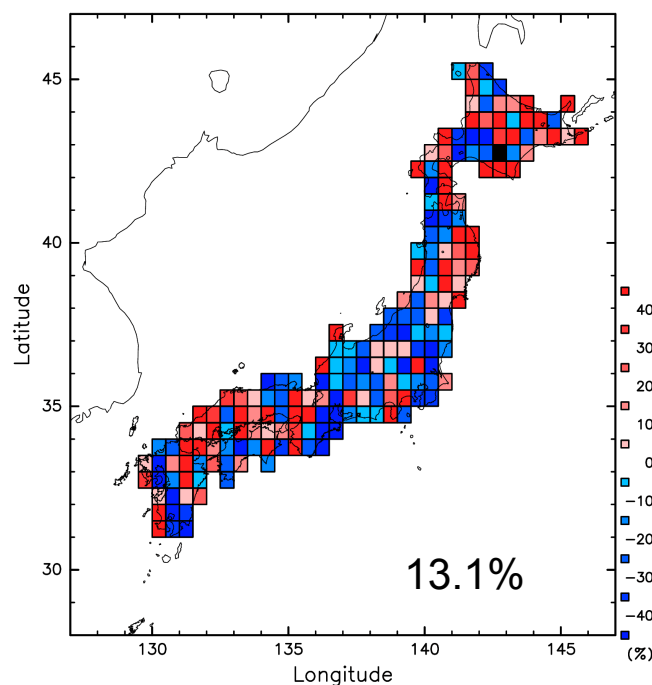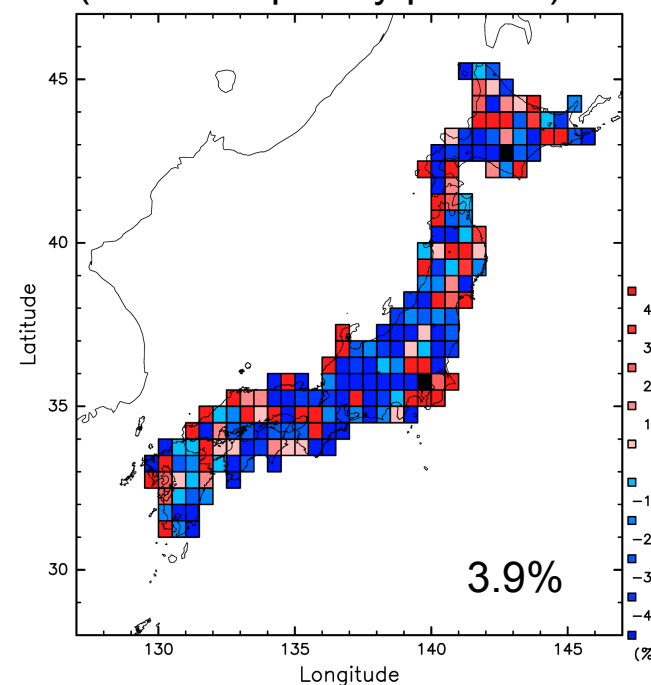
- In rain cases only **(surf Temp. >6 C)**, the underestimation area is reduced in Japan.

Global Satellite Mapping of Precipitation (GSMaP)

3-hourly movie from 3 to 9 November, 2013 (Typhoon Haiyan case)

2013-11-03 00:00 - 00:59 (UTC)
Rainfall by GSMaP   IR Image (c)JMA/EUMETSAT/NOAA   Background Image by ADEOS-II/GLI
Rain 0.1   0.5   1.0   2.0   3.0   5.0   10.0   15.0   20.0   25.0   30.0 [mm/hr]

❄ GSMaP is a blended Microwave-IR product and has been developed in Japan toward the GPM mission.
   ❄ U.S. counterpart is "IMERG"
❄ Proto-type version has been in operation in JAXA since 2007
   "GPM-GSMaP" data were released on Sep. 2014.
   ❄ GPM-GSMaP data for TRMM period is currently processing as reanalysis version (GSMaP_RNL), and will be distributed soon.

Evaluation of GPM-GSMaP (1/2)

Daily averaged rainfall around Japan in 0.25 degree grid was compared with JMA's Radar AMeDAS (gauge-calibrated radar analysis rainfall).
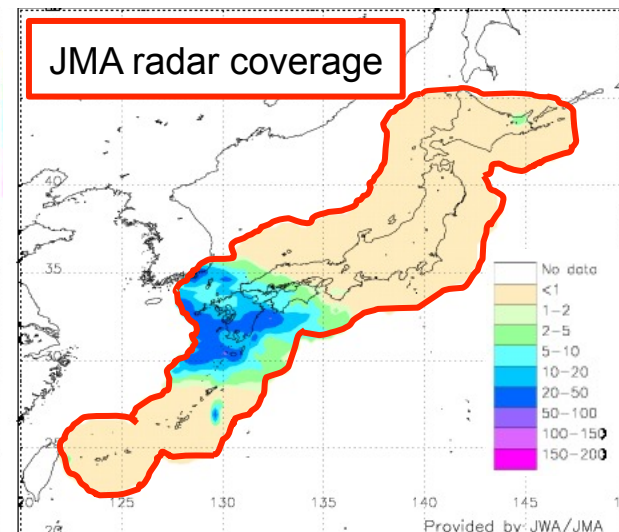
An example on Apr. 12, 2014
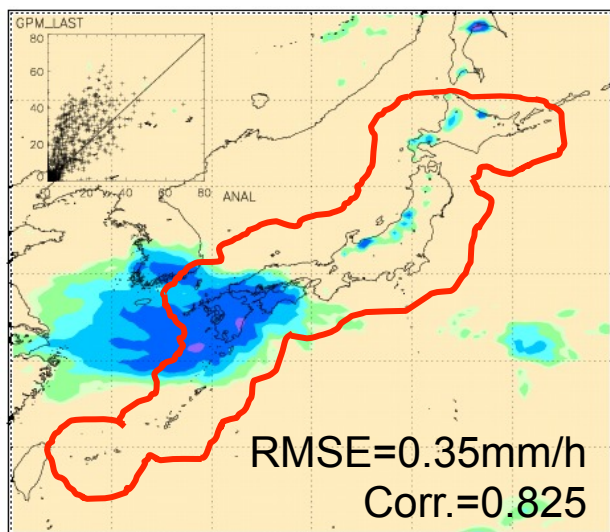
GSMaP_MVK **GSMaP_Gauge** **Gauge-Radar Analysis**
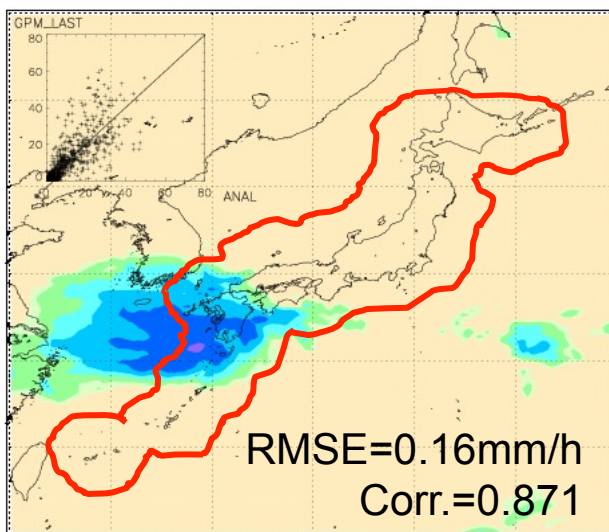
RMSE=0.35mm/h
Corr.=0.825

RMSE=0.16mm/h
Corr.=0.871

JMA radar coverage

→ **GSMaP_Gauge** shows better correlation with less Root Mean Square Error (RMSE) on Apr. 12, 2014.

Evaluation of GPM-GSMaP (2/2)

Daily series (15-day running mean) of Root Mean Square Error (RMSE) for GSMaP product with reference to JMA radar-AMeDAS data during Mar. 1 to Nov. 30, 2014
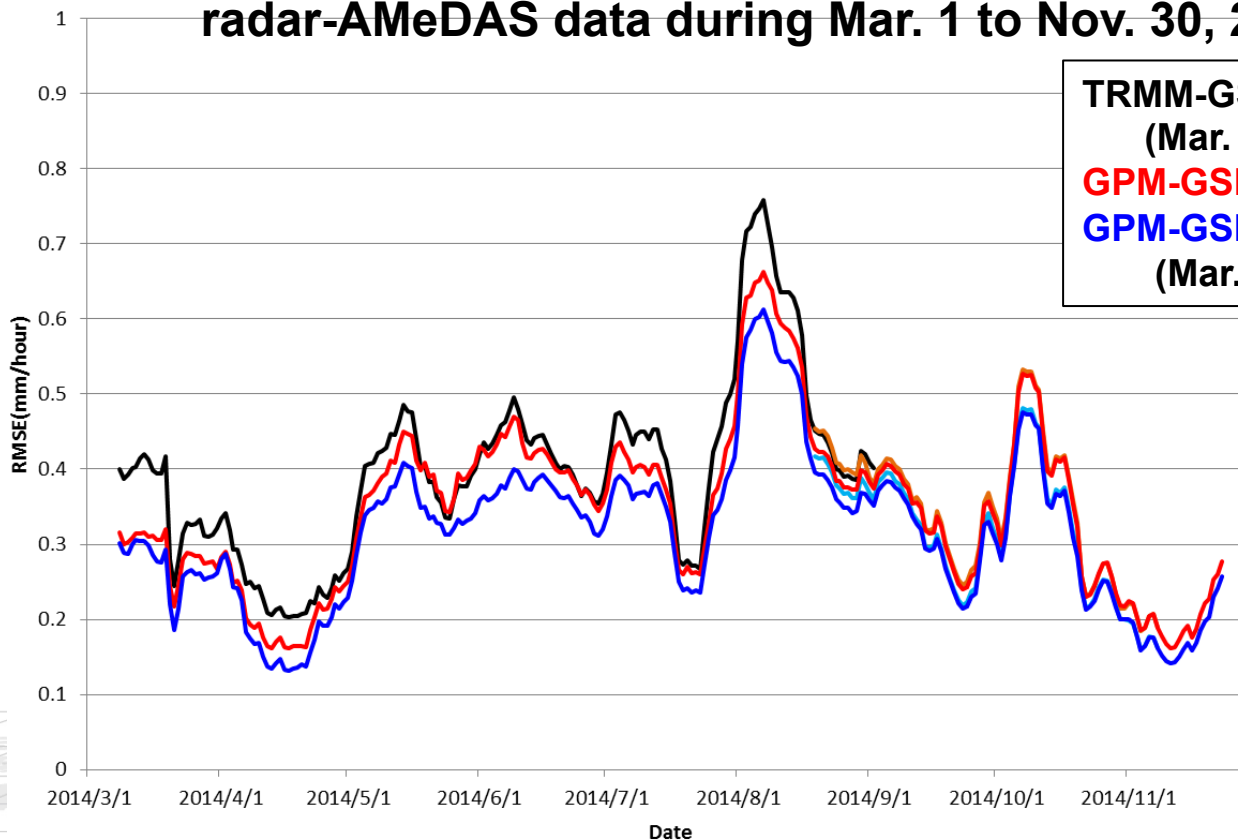
TRMM-GSMaP_NRT (Mar. 1 ~ Sep. 2)
GPM-GSMaP_MVK (03C)
GPM-GSMaP_Gauge (03C) (Mar. 1 ~ Nov. 30)

Better

- **GSMaP_Gauge** shows the least RMSE.
- Mean RMSE values of GPM-GSMaP products are smaller than those of the **TRMM-GSMaP_NRT (v5)**.

Development of GSMaP nowcast version (GSMaP_NOW)

* To reduce latency from 4-hr to nowcast
  * <u>Using data that is available within 1-hour</u> (GMI, AMSR2 direct receiving data, AMSU direct receiving data and MTSAT) to produce <u>GSMaP at 1-hr before</u> (observation).
  * <u>Applying 1-hour forward extrapolation</u> (future direction) by cloud moving vector to produce <u>GSMaP at current hour</u> (nowcast).
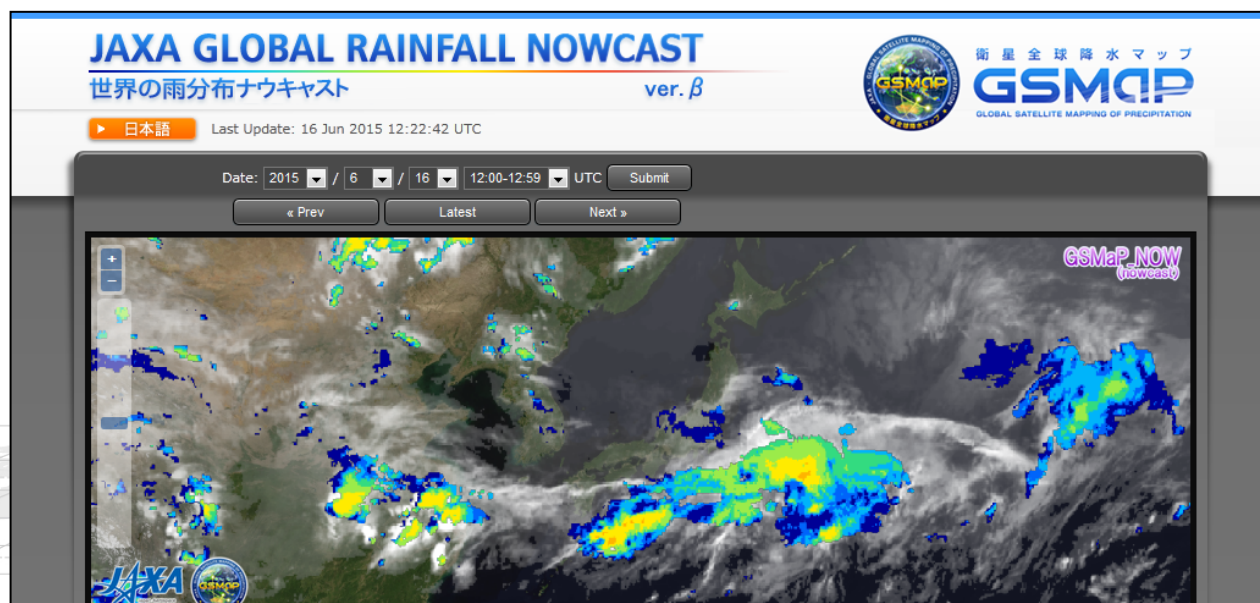
* Web site and image is now open to limited users, and will be released to the public in this summer.

# Japanese GPM GV field campaigns

* ## Algorithm validation
  * Dual Ka-band radar observation campaigns had finished.
  * k-Ze relationships about rain, snow, snow aggregate, and melting layer are measured.
  * The assessment of the model and parameter in DPR algorithm is the next topic.
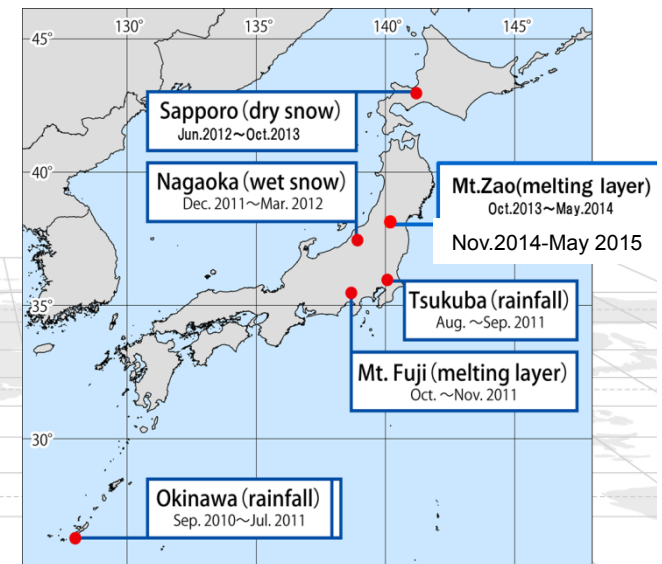* ## Product validation
  * By calculated Z from the DSD data with ground instruments(Parsivel, Disdrometer, 2DVD), Z of DPR will be evaluated.
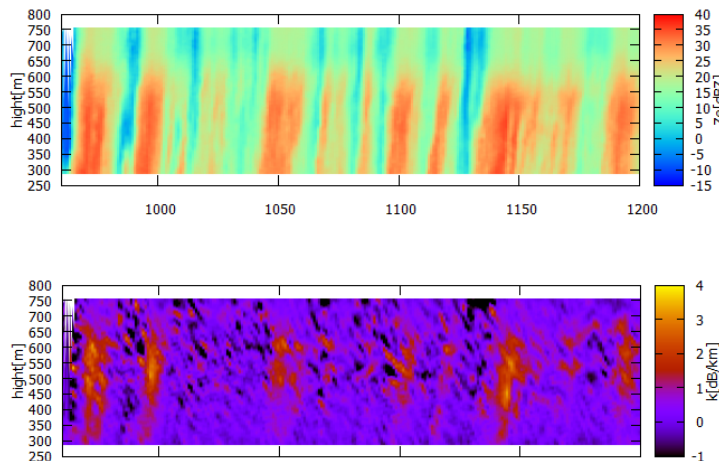
Top: Ze from Dual-Ka radar Bottom: k from Dual-Ka radar
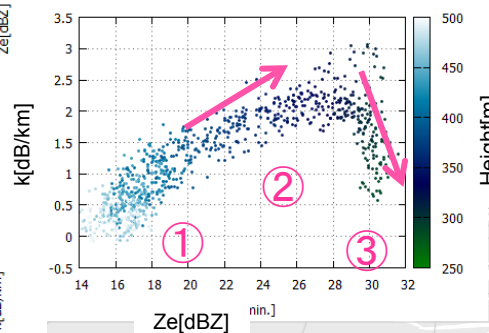
k-Ze relationship in upper part of B.B.
(1:snow,2:melting,3:rain)

The sites for algorithm validation

Ship-based GV field campaign for tropical oceanic precipitations in 2015 with JAMSTEC
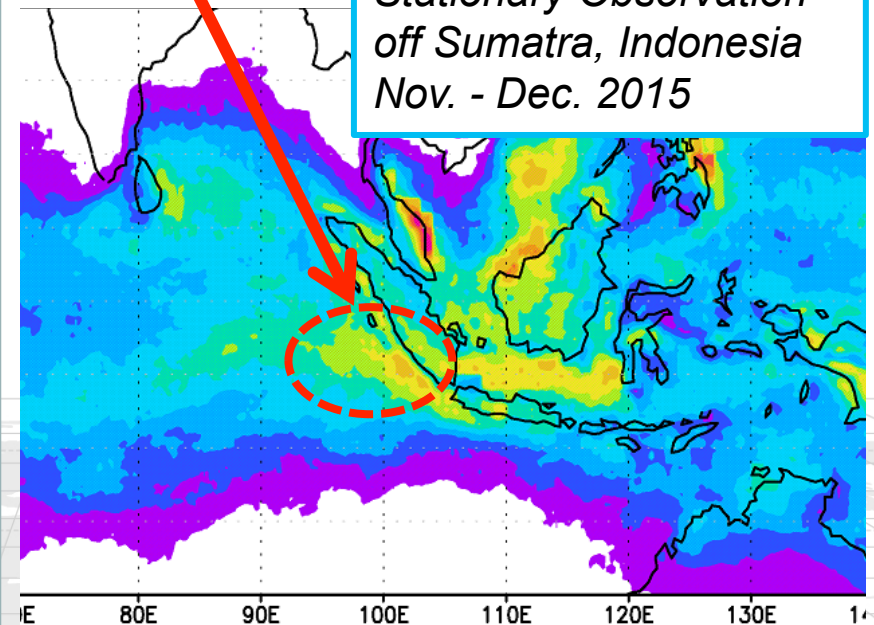

R/V Mirai

Ka-band VP radar

Radiosonde (3-hourly)

Disdrometers

C-band dual-pol. radar

Stationary Observation off Sumatra, Indonesia Nov. - Dec. 2015

GMI data assimilation experiment in JMA

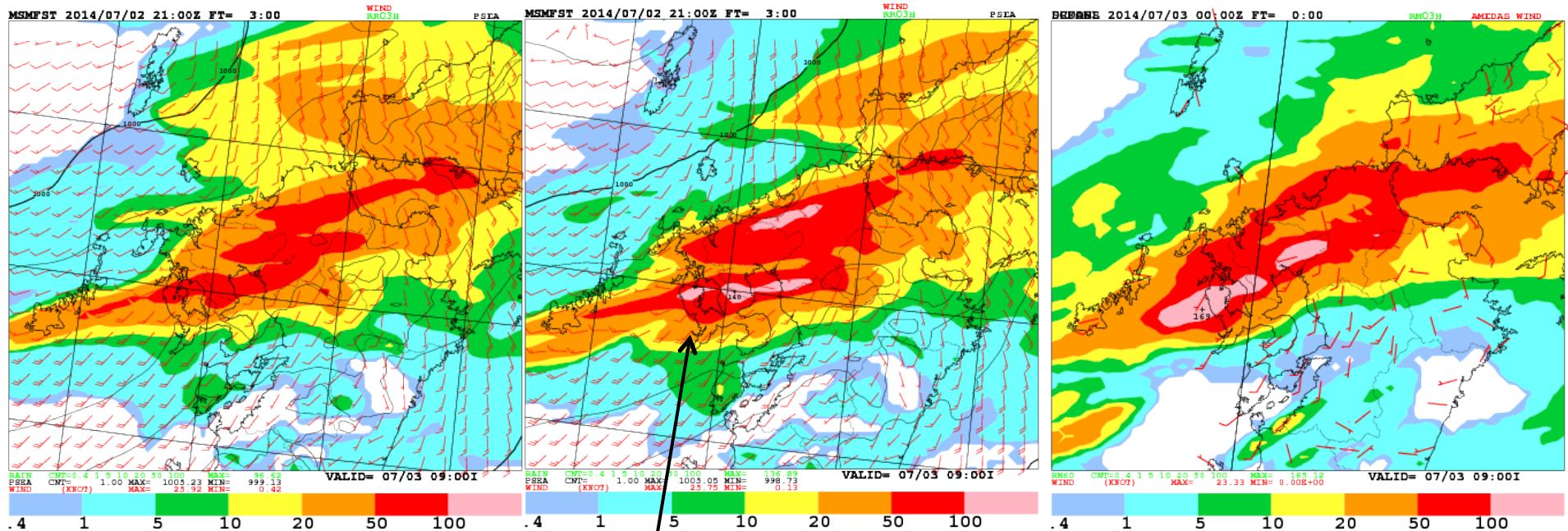Three hour accumulated rainfall **forecast for 00UTC July 3, 2014**
Three hour forecast from **initial time** (**21UTC July 2, 2014**)

Control   **Test**   **Radar Observation**

Locally, there is better agreement in heavy precipitation area
(Red area: 50 - 100 mm/3hr)

What is the reason of the improvement?
Deeper low pressure system in **Test**
Surface pressure gradient is steep than Control over the northern Kyusyu Island.

(Kazumori, 7th IPWG, 2014)

Summary

* The Japanese PMM Science Team started in Apr. 2013 for three-year period.

    * 30 proposals for the 7th RA (JFY2013-2015) .

* The next annucement will be in this Summer, 2015.

* TRMM

    * Completion of PR on 1st April 2015

    * TRMM/PR EOM (End of Mission) Status

* GPM

    * GPM Core Observatory and instruments are working well.

    * GPM products V03 are released to public in Sep. 2014.

    * Evaluation of DPR L1, L2, and GPM-GSMaP for data release.

    * Ship-based GV field campaign for tropical oceanic precipitations in 2015 with JAMSTEC

* GSMaP earlier latency product (GSMaP_NOW) is now open to limited users, and will be released to the public in this summer.